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COVER SHEET FOR TECHNICAL MEMORANDUM

TITLE- Failure Impact and Backup Capability of Saturn Launch Support ESE at KSC

TM- 67-2032-2

DATE- June 5, 1967

FILING CASE NO(S)- 330

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FILING SUBJECT(S)- Launch Systems ESE
(ASSIGNED BY AUTHOR(S)-

ABSTRACT

The principal ESE used for Saturn launches is examined with regard to failure impact and alternate support capability during critical operations. Of the 23 systems examined, nine systems, which are classified "mandatory" in the AS 501 Launch Mission Rules, operate without complete redundancy or alternate support provisions.

When a system is classified "mandatory," it is implied that the system has a mission-essential function; therefore, it appears logical that these preflight systems should be treated in the same manner as essential flight-support systems.

It is therefore recommended that the appropriate Centers review the criticality of these systems and identify any actions required to assure that failures in any of them will not jeopardize mission success.

The requirements of dual-launch missions should be considered in these reviews.

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SUBJECT: Failure Impact and Backup Capability of Saturn Launch Support ESE at KSC - Case 330

DATE: June 5, 1967

FROM: V. Muller

TM 67-2032-2

TECHNICAL MEMORANDUM

I. GENERAL

A historical survey of 169 Atlas, Titan and Saturn I launches at Cape Kennedy shows that 105 scrubs occurred; 54 percent of these scrubs were attributed to vehicle, 33 percent to GSE[1] malperformance, and 13 percent to inclement weather. Of the 35 scrubs caused by malfunction of GSE, some 20 percent involved Electrical Ground Support Systems.

In the case of lunar landing missions, scrubs become much more critical. A scrub occurring late in the countdown will most likely cause missing of a launch opportunity, and result in impacting areas of national interest like prestige and expenses. Recycling of the complete mission system, KSC, MCC-H, MSFN, ETR, recovery forces, loss of consumables and contractor man hours results in specifically assessable expenses. Other penalties include wear out of the hardware, particularly flight hardware, which becomes subjected to additional test operations and adverse climatic environment.

It is not intended to use the past record of scrubs as a measure to predict the number of Saturn V scrubs that may be caused by ESE, but rather to show that they can be expected to occur. With the increased dependency on ESE systems, as compared to the early ESE/GSE operational support, more ESE failures and an even larger impact on the launch operations can be anticipated.

Scrubs caused by the flight hardware have to be expected and dealt with within mission constraints and flight hardware requirements. However, scrubs caused by the ground-based systems should be kept at the conceivable minimum.

Although the report emphasizes Saturn V support, it is, with few exceptions, also applicable to the Uprated Saturn I Vehicles and facilities.

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[1]For abbreviations, see Attachment 2.

II. OBJECTIVE

In order to assess possible ESE failures causing a scrub, each principal ESE system participating in the countdown of Saturn Vehicles is examined. The impact, in case of failure of each system, is determined and the availability of redundant functions or alternate support capability is examined. As a result of this study, the most critical systems or functions are identified. The critical systems are as classified, based upon their being mandatory to support countdown and launch operations but have no provisions for complete redundancy or alternate support.

Other related problem areas are identified which include secondary constraints arising from the redundancy or backup requirements.

The systems classified as "mandatory" are the same as specified in the AS 501 Launch Mission Rules. Mandatory is defined as being essential for accomplishing a specific mission. As a result, the mandatory assignment to a system means that the operations cannot proceed if that system fails late in the countdown.

For the purpose of this study, certain ground rules, with respect to the provisions of alternate support, are observed in the following order of criticality:

1. Each organization shall retain its assigned responsibility in the overall task of launch preparation and launch support.

2. No degradation of the supporting function shall be introduced.

3. Existing facilities are considered and addition of hardware is avoided as much as possible.

A system-by-system analysis is included as Attachment 1.

III. SUMMARY

The principal ESE to support Saturn launches at KSC has been examined with regard to failure impact and alternate support capability during critical operations.

Of the 23 principal systems examined, nine of the systems, which are classified "mandatory" in the AS 501 Launch Mission Rules, operate without complete redundancy or alternate support provisions. These systems and the related criticalities in case of failure are listed below:

1. KSC Timing System: the distribution and sub-timing systems are not always available in a redundant configuration or with an alternate support capability. They are required for the operation of mandatory ESE. (See Section 1.1.)

2. Terminal Countdown Sequencer: cutoff and subsequent reset requires some four hours. (See Section 1.2.)

3. RCA-110A system, specifically the LUT computer system: loss of discrete output switch selection and control. (See Section 1.3.)

4. Mission Support Room (LVO): loss of specific mission rule measurement monitor, firing room and MCC-H support. (See Section 1.5.)

5. Digital Data Acquisition System (DDAS): loss of flight TM systems checkout capability during open-loop test and loss of LV checkout data during closed-loop test to LCC, MSR, ALDS and LIEF. (See Section 1.6.)

6. Digital Event Evaluation System (DEE): loss of data monitor during propellant loading and environmental tests. (See Section 1.7.)

7. Data Transmission System (DTS): loss of monitor and control capability of pad critical GSE. (See Section 1.8)

8. USB command link: loss of AGC and LVDC update capability and loss of real-time command capability (Abort Advisory and LVDC backup). (See Sections 1.18 and 1.23.)

In addition to the systems listed under 1 through 8 above, some additional systems contain a set of special problems:

a. ACE-SC requires a second station for alternate support capability during critical test operations. Scheduling requirements must reflect this mode of operation.

b. Hardline Communication: Catastrophic events (fire, power loss) in central facilities such as CDSC, VABR, BRR disable all basic capability for hardline communications.

IV. CONCLUSIONS

Supporting functions which are classified as "mandatory" are, by definition, functions which are essential for accomplishing a mission.

The Apollo Program Specification, SE 005-001-1, Rev. A, specifies in Section 3.1.3.3.4 ..... that no single failure shall prevent the successful continuation of the mission ..... Although this statement is primarily directed to vehicle and flight-support systems, it appears that, with the assignment of mandatory, the criticality of prelaunch ESE approaches that of the ground support systems used during flight.

In consideration of the above, it seems appropriate to recommend that the appropriate Centers review the criticality of these systems and identify any actions required to assure that failures in any of them will not jeopardize mission success.

The requirements of dual-launch missions should be considered in these reviews.

ACKNOWLEDGMENT

The author wishes to express his appreciation to all the NASA/KSC, ETR and associated contractor personnel who have been helpful in accumulating and reviewing the presented information. Particular acknowledgment goes to KSC/HC, HD, JA, KA, PA, QA, GSFC/USB, ETORS and associated contractors.

V. Muller

2032-VM-gmp V. Muller

Attachments
1 - Systems Analysis
2 - List of Abbreviations

ATTACHMENT 1

SYSTEMS ANALYSIS

Table I presents a list of principal ESE systems participating in the countdown. Included are KSC outlying systems, such as ETR, MCC-H and LIEF, since their functions present an integral part of KSC operations support.

TABLE I

KSC Timing System	PTCS
Terminal Countdown Sequencer	Facility Comm. OIS
RCA-110A Computer System	KSC Tracking
LCC Data Display	ALDS
LVO Mission Support Room	MCC-H
DDAS	USB-Station
DEE-3, DEE-6 Systems	LIEF
DTS	ETR Timing System
ACE-SC	Range Safety System
CIF TM Station	Hardline Comm. System
CIF Data System	Open Loop Comm. System
LCC TM Station	

Figure 1 depicts the principal Data Distribution Network, which is either part of the systems listed in Table I or interfaces within these systems. The network shown includes only the basic Telemetry and Command Links in the open or closed loop configuration.

In the following sections, each system listed in Table I is discussed with regard to interface requirements, failure impact and alternate support capability. Selected related problem areas are included.

1.1 KSC Timing System

a. Configuration

The KSC Timing System generates and distributes time and frequency signals with ± 10 milliseconds accuracy. The timing generation equipment is located in the CIF; part of the timing distribution system is the countdown clock. The Timing and Countdown systems provide some 150 inputs to such functions as countdown displays, GMT, discrete frequencies, sequence control and event signals. Subtiming stations at MSOB, LCC, VAB, LUT and PTCR receive and distribute the timing signals for local users such as the RCA-110A system and ACE-SC. Calibration is accomplished through WWV, VLF and Loran C transmitters; synchronization with ETR occurs through cable interface at BRR and via UHF at the CIF.

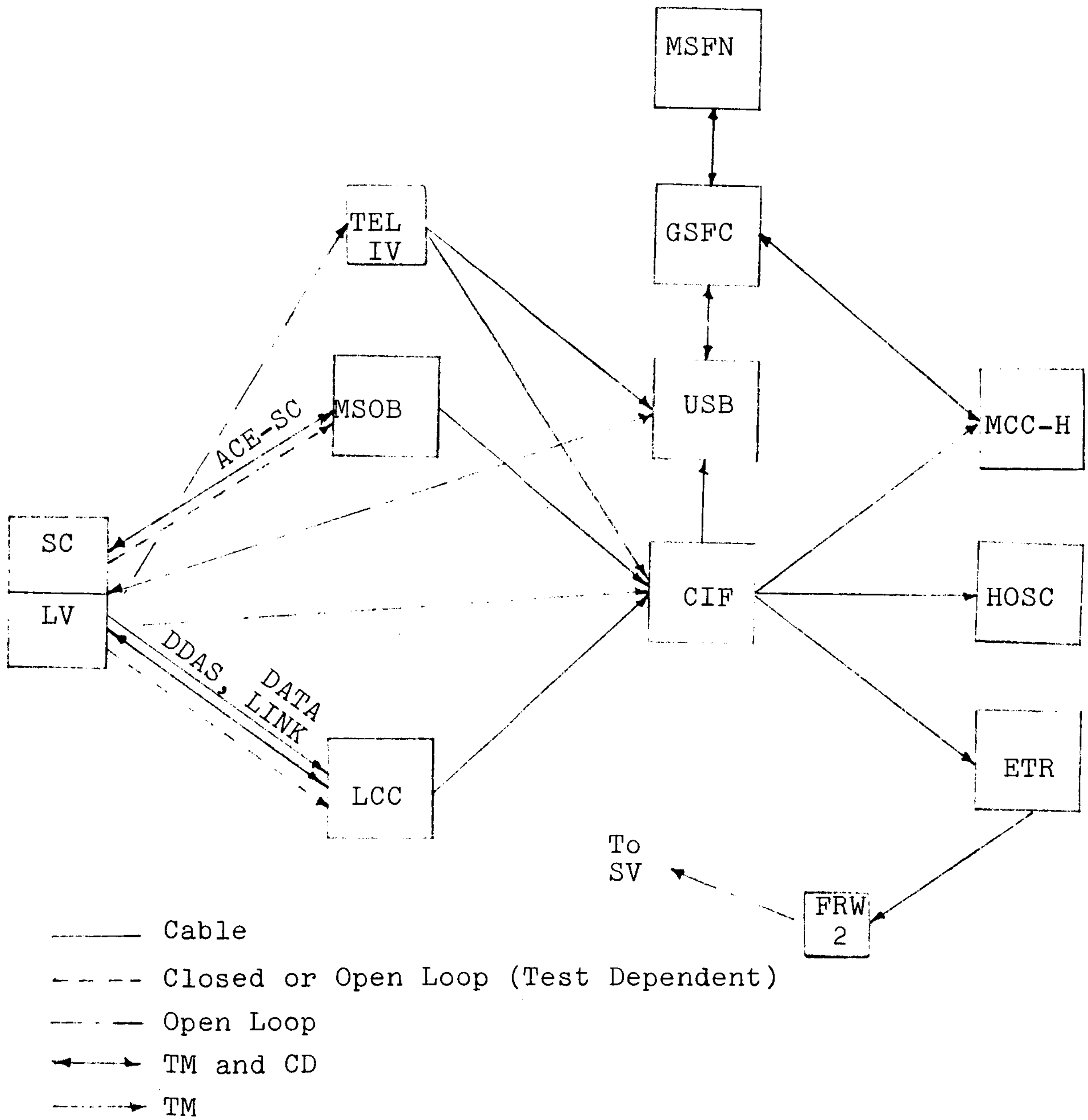

FIGURE 1

PRINCIPAL DATA DISTRIBUTION NETWORK

b. Failure Impact

Failure of the Timing and the Countdown Systems disables most ESE support functions. Loss of momentary synchronization necessitates a hold and successive reinitialization of the timing system users. Loss of synchronization can occur through loss of timing generation, distribution systems failure or through temporary surge of power.

c. Alternate Support

The timing generation system operates in two identical sets, on a redundant standby basis. Switchover is accomplished manually.

Power backup exists by means of standby batteries in the CIF.

In addition, alternate timing signals can be provided through manual patching to the ETR timing system. However, the distribution and subtiming systems do not provide complete redundancy and most of the distribution network and subtiming systems operate on facility power.

1.2 Terminal Countdown Sequencer (TCS)

The TCS is a solid state device, located in the LUT sequence rack.

Between T-187 sec. and T+20 sec., the TCS initiates some 48 timed functions through operating output relays in a prearranged sequence. These functions include fuel tank pressurization, transfer to internal power, termination of bubbling, turbopump bearing heater cutoff, umbilical arm disconnect, ignition sequencer start, etc. The TCS is started after completion of the interlock chain preparation and manual closure of the Firing Command Enable Switch in the Terminal Sequencer Panel of the LCC. Timing control of the TCS is provided through a 1-pps signal from the countdown clock. Interrupt of the TCS can occur through interface chain cutoff or manual cutoff, necessitated in most cases by a launch vehicle systems anomaly.

TCS monitor and interlock status is available through the RCA-110A data link, ground DDAS, DEE equipment and special hardwire. Discrete Output Control by the RCA-110A computer, however, is inhibited during TCS operation.

b. Failure Impact

In addition to cutoffs initiated by the interlock system, loss of countdown timing or TCS failure generates an interrupt. Current estimates show that a TCS reset and recycle, without repair, would at least require some four hours.

c. Alternate Support

No alternate support capability exists in case of TCS failure.

1.3 RCA-110A Computer System

a. Configuration

The LUT based RCA-110A computer system provides the LVDC interface, performs the switch selection, monitors and controls the discrete outputs, monitors the DDAS and contains the discrete action tables.

The LCC RCA-110A computer controls the test execution and provides the display service.

Interfacing with the RCA-110A system are the ground and stage DDAS, DEE-3, PTCS, Display Computer (DDP-224), PTCS, and ACE-SC. The RCA-110A also provides an input (preparations ready) for enabling initiation of the TCS.

b. Failure Impact

Failure of the LUT RCA-110A or associated in/output and signal distribution equipment disables switch selection, discrete output control and inhibits G&C systems testing.

Failure of the LCC computer or associated in/output distribution equipment disrupts the LCC function execution control and display console service.

Operation of the LUT computer is a prerequisite for the start of the TCS, and LCC computer operation is mandatory for DDP-224 computer operation.

c. Alternate Support

No alternate support capability exists for performing LUT computer switch selections and discrete in/output control, except for limited hardwire controls.

A manual switch selection and discrete output control capability exists between the LCC and backup LUT RCA-110A operations. However, manual control of 2048 discretes is very cumbersome and impossible within the time constraints of the countdown operations. Therefore, manual control is only planned for some 4-6 discrete operations at the end of launch countdown (no T-time estimate available).

Additional hardwires are available for emergency safing.

LV and ESE status monitoring in the LCC is available independently of the RCA-110A computers, by means of the DEE-6, DEE-3, DDAS and CIF telemetry systems. Each backup system drives its own displays, recorders, indicators or printers to provide the LCC man/equipment interface.

Preparations are being made to provide the CIF telemetry data via DDP-224 computer to the Sanders displays upon request. This would provide for redundant monitoring capability; however, it would limit backup capability in case of DDP-224 computer failure.

1.4 LCC Data Display and Control

a. Configuration

The LCC Data Display and Control consoles are located in the LCC firing rooms. They provide for manual initiation of test programs, manual interruption of programmed events and contain the CRT (Sanders) displays, event lights and analog meters. Command and display interface between the consoles and the RCA-110A computer is provided by the DDP-224 computer system.

b. Failure Impact

Failure of individual display and control console equipment disables the monitor and manual control function of a particular stage or system.

Failure of the DDP-224 system disables the console main displays and the manual control capability by the systems test engineers in a firing room. Availability of principal LCC Data Displays is mandatory for launch operations and launch.

c. Alternate Support

Individual display and control consoles can be backed up by other consoles through insertion of a coded card, thus enabling alternate program callup for display and control support. In case of complete loss of the DDP-224 operated displays and controls, partially alternate data presentation is available from the DEE-6, DEE-3, DDAS and CIF equipment. These alternate data presentations are, however, not always feasible for real time data analysis.

Limited manual control of discrete outputs and emergency operations can be performed through direct hard-line links. Increased computer program control and, hence, elimination of the man/machine interface is possible through progressive automation.

1.5 LVO Mission Support Room (MSR)

a. Configuration

The MSR is located in the CIF and is used by LVO to monitor real-time data from Uprated Saturn I or Saturn V launch vehicles during prelaunch, launch and postlaunch operations.

The MSR is manned by LV Systems Engineers whose responsibilities include (1) monitoring of mission rules measurements, (2) backing up the LCC on other critical measurements, and (3) directly supporting MCC-H flight control operations. The LV information is presented on trajectory displays, CRT displays, strip charts, recorders and video displays. All data is available from the CIF Data Core; CRT displays are driven by the GE 635 computers, the other displays are directly driven. Direct OIS interface exists with the LCC firing rooms, MCC-H and HOSC.

b. Failure Impact

Malfunction of the MSR results in the loss of a mandatory function during prelaunch and launch operations and a highly desirable function during the powered phases of a mission.

c. Alternate Support

The MSR performed functions are not redundant to LCC, HOSC or MCC-H functions. Each of these functions, such as monitoring of launch mission rules (limit check of critical parameters), systems engineering support, LVO flight controller operations for evaluating systems performance and dynamic trends of the navigational system, electrical network, mechanical and propulsion systems, or Abort Parameter monitoring and LIEF operations support are uniquely defined and have individual equipment provided.

No alternate support is available.

1.6 Digital Data Acquisition System (DDAS)

a. Configuration

The DDAS is located in the LUT base and the LCC and is used for transmitting real-time data from the Launch Vehicle systems and the GSE to LCC facilities for quick-look display by means of the measuring system and for data processing by the RCA-110A computers. The DDAS is required for the S-IC, S-II, S-IVB, IU and GSE. DDAS provided checkout data is sent also to the CIF for display processing and transfer to ALDS and LIEF equipment.

During TM open-loop tests, the DDAS is required for TM systems checkout.

b. Failure Impact

Failure of the DDAS disables part of the real-time CRT display inputs including all DDAS recordings and indications of the LCC measuring system, and reduces checkout data availability to the CIF, ALDS and LIEF, particularly during closed loop transmission phases. The high sampling rate data of the DDAS is required to the ALDS for readying MCC-H equipment and determining baseline data files. Hence, ALDS and DDAS availability is mandatory prior to launch. Other mandatory requirements for DDAS availability exist for LV or TM systems open-loop tests.

c. Alternate Support

Most of the information carried over the DDAS can be obtained in the firing room via the RCA-110A system. Selected parameters are also supplied through the DEE-3, DEE-6 and direct measuring system.

Flight TM data is presented open loop to the LCC TM and CIF TM stations or closed loop to the LCC TM station. The Flight TM data, however, does not contain the high rate data required for prelaunch checkout and which is mandatory for LV TM systems open-loop tests, ALDS, LIEF and MSR.

No backup capability is provided in support of the DDAS for all the mandatory functions during open-loop tests and no complete redundancy exists between the LCC (DDAS) and CIF terminal equipments.

1.7 Digital Event Evaluation System (DEE)

a. Configuration

The DEE System consists of two similar computer systems, the DEE-3 and the DEE-6. The DEE-3 computer is located in the LCC; the DEE-6 computer is located in the LUT base.

The DEE System is used to monitor and record a total of 2832 time critical discrete events and to flag any discrepancy between actual and programmed event sequences. The DEE-3 monitors those events which are associated with propellant loading, environmental control and astrionics systems. The larger capacity DEE-6 is used to monitor other discrete events. DEE System status information is presented on printers and event lights in the LCC for real-time evaluation.

b. Failure Impact

Failure of the DEE Systems operation results in loss of the real-time monitor capability of the LV propellant systems which is mandatory during countdown and launch operations.

c. Alternate Support

All DEE Systems provided information is available either via RCA-110A system (90%) or DDAS. However, this data, particularly that furnished by DDAS, is not presented on equipment and in a format suitable for real-time evaluation.

Hence, no proper alternate support capability exists during countdown.

1.8 Data Transmission System (DTS)

a. Configuration

The DTS carries some 1400 control and monitoring signals between the LCC firing room and the PTCR in a serialized PCM format. The DTS interfaces with the RP-1 systems, LOX system, LH_2 system, RCS, PTCS, pad safety equipment, power control and distribution equipment, nitrogen and helium system. Status displays located in the firing rooms provide for DTS status information.

b. Failure Impact

Failure of the DTS transmission or PCM conditioning equipment results in loss of critical GSE control and monitor functions.

c. Alternate Support

No alternate control capability is available except for emergency safing; selected status information is provided via the alternate routes of DDAS and special hardlines.

1.9 Acceptance Checkout Equipment Spacecraft (ACE-SC)

a. Configuration

Major ACE-SC equipment is located externally to the spacecraft on the MSS and in the MSOB computer and control rooms.

In the downlink, real-time spacecraft data is collected, signal conditioned, commutated, and transmitted to the MSOB via hardlines, then decommutated, and evaluated by the CDC 160G computers for display and record. Other displays, such as meters and event lights are directly driven from the decommutators.

In the uplink, test commands from the MSOB control-room consoles are encoded by the command computer, transmitted to the spacecraft vicinity equipment for conditioning to initiate required relay operations.

b. Failure Impact

In the downlink, loss of either decommutator results in loss of either the interleaved SC/GSE systems status information, or the airborne systems status information.

Loss of downlink computer results in loss of CRT display capability, including the limit checking feature and some recording capability.

Loss of individual display systems disables individual system displays for real-time evaluation.

In the uplink, failure of the command computer results in loss of remote command control capability, except for emergency safing via special hardlines.

Loss of individual systems control consoles restricts particular systems control. Failure of the spacecraft vicinity equipment inhibits partial or complete ACE-SC operations.

c. Alternate Support

The decommutators can be programmed to provide backup capability in case of loss of either equipment. However, progressive automation through implementation of the Decom Mod will no longer allow for this redundancy feature.

Increased ACE-SC automation reduces the need for control console availability.

Switching and patching facilities exist which allow for interchanging computer rooms and control rooms of the four** ACE-SC stations in the MSOB. However, since the configuration, particularly that of the control rooms, vary, depending on the supported spacecraft, and since the computer and decommutator programs have to be reloaded and reverified, switchover is not easily accomplished. For this reason, previous ACE-SC operations support during countdown had been performed with one complete station operating in parallel (from T-32 hours). This mode of operation will most probably be maintained for future launches.

Since earlier tests, such as OAT #2, CDDT and FRT, might likewise be critical for meeting a specific launch window, similar ACE-SC utilization might become necessary during those tests. However, in view of the presently limited number of available ACE-SC stations, this would necessitate increasing the number of stations.

1.10 CIF Telemetry Stations

a. Configuration

The CIF Telemetry Station is located in the CIF building and is used to accept, condition and process telemetry data for wideband transmission, computer input, record and real-time displays.

Incoming data includes Spacecraft data from MSOB (ACE-SC), Launch Vehicle data from the LCC Telemetry Station (DDAS, open or closed loop Flight TM data) ETR/RTCS; Space Vehicle data from MCC-H (remote sites and ALDS), MILA USB site and VMF (Tel IV). Other inputs are received at the CIF Antenna Field and CIF roof antennas and include LV telemetry, flight television and vehicle tracking signals (ODOP).

Outgoing data is stored in the Data Core for transmission to MCC-H (ALDS), GSFC, ETR/RTCS, MSFC (LIEF), and for distribution to CIF Data Processors for CIF, LCC and MSOB special display systems and direct analog and event displays and recorders.

The TM station is composed of four modules, each of which can be operated independently or in a combined configuration. A module reflects a particular CSM/LV configuration and is committed to a vehicle from FRT through launch. Two modules are used to drive the redundant ALDS system in

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**KSC now has four ACE-SC stations; there is a possibility of this being increased to five in the latter half of 1967.

parallel and the design criteria include two simultaneous launch support requirements, which account for the four available modules.

b. Failure Impact

Failure of a telemetry station module and peripheral equipment disables the Data Core inputs and, therefore, telemetry data availability to remote users, such as ALDS and LIEF. The latter support requirements are mandatory for countdown and launch.

c. Alternate Support

Redundant ALDS operation, from FRT through launch, necessitates two simultaneous telemetry inputs and, therefore, requires completely redundant operation of two telemetry modules. If the requirement to support two simultaneous launches is deleted, additional equipment is available to support ALDS operation in case of a telemetry station module failure.

Although Flight TM data is provided to MCC-H via USB site and GSFC, the low-bit data rates (2.4 kbs) of this link, including the longer delay times, do not provide sufficient backup capability.

In addition, the CIF TM Station represents the point of ETR interface with KSC.ETR inputs are provided on redundant wideband links and via UHF.

Failure impacts of individual CIF interfacing systems are discussed under the appropriate headings.

1.11 CIF Data System

a. Configuration

The principal CIF data system is comprised of the two GE 635 computers, which are used for on-line processing of telemetry data for quick-look evaluation and display. Interfacing with the GE 635 are the CIF telemetry station via Data Core and the CIF display system in the CIF (MSR) and LCC Firing Rooms. Other GE 635 functions include scientific data processing and administrative data handling.

Additional data systems include two special-purpose computers which are used for supporting data transmission to LIEF and two Univac 1004 computers for card handling and printout generation in support of the GE 635, GE 235 and RCA-110A computers; a third Univac 1004 is used for countdown documentation preparation.

The GE 235 is used in support of the GE 635 computer for on-line TM data processing and scientific data reduction, particularly in the area of G&C systems performance evaluation.

In addition, two SDS 930 computers reduce telemetry data for ALDS data transmission and a GE 415 computer is used for test-tape generation and documentation preparation.

An integral part of the CIF Data System is the Data Core, which is capable of receiving PCM, PDM, PAM and analog signals for conditioning and storing in a digital format. Input sources include LCC TM, DDAS hardlines, CIF antenna (telemetry) systems and ETR signals, both local and downrange. User systems include quick-look displays, the telemetry ground station, the ALDS and LIEF real-time transmission systems and the GE 635 real-time programs.

b. Failure Impact

Failure of the GE 635 and GE 235 systems disables the real-time CIF display system in the CIF (MSR) and LCC Firing Room, and causes loss of some scientific data preparation.

Real-time displays driven by the GE 635 computer are required for proper MSR operation, which is mandatory during prelaunch, launch and powered flight. The LCC support by the GE 635 and GE 235 computers, however, presents a secondary function.

Loss of the ALDS and LIEF support systems (SDS 930, LIEF special-purpose computers and Data Core) are discussed in Sections 3.16 and 3.19 on ALDS and LIEF, respectively.

c. Alternate Support

Although there are two GE 635 computers available, complete redundancy or backup support does not exist for MSR operation. (See Section 3.5.)

Since the CIF support functions for the LCC are of a secondary nature, sufficient backup is available and all computations for systems (particularly G&C) evaluation and data processing for display and record, are provided through primary launch operations support systems, such as the RCA-110A and DDAS systems.

Support of mandatory functions such as for ALDS and LIEF are provided in redundant fashion, including Data Core and data processors.

1.12 LCC Telemetry Station

a. Configuration

The LCC Telemetry Station is used to evaluate the performance of each LV telemetry link during prelaunch tests and to receive and condition telemetry data during integrated tests and launch. The TM station is located on the second floor of the KSC-LCC building and operates open loop to antennas on the roof of the LCC while the vehicle is at the pad. Telemetry inputs consist of PAM/FM/FM, PCM (video receiver and DDAS) and SS/FM signals. The information is transmitted from the LCC TM station via hardline to the CIF Data Core.

b. Failure Impact

Failure of the LCC TM station inhibits checkout and monitoring of the LV TM systems. These checkout operations are mandatory for countdown and launch.

Loss of DDAS and TM information to the CIF disables Data Core TM inputs. Availability of this data is mandatory for ALDS and LIEF support.

c. Alternate Support

Telemetry monitoring and data distribution is primarily obtained by the DDAS and RCA-110A systems during closed-loop tests.

Additional open loop TM transmission links exist in S-Band to the USB site and from there in hardline to the CIF Data Core or via GSFC to MCC-H; and in VHF via Tel II or via CIF antennas (selected S-Band also) to the CIF Data Core.

Data Core inputs from DDAS (PCM), LCC TM (FM/FM, PCM, PAM) or CIF TM (FM/FM/PCM/S-Band) are provided on three separate links and are selected alternatively. The LCC/CIF interface links consist of A2A wideband links for the DDAS information and 19 gauge lines for the LCC TM data. Limited backup is provided. (See Section .22.)

1.13 Propellant Tanking Computer System (PTCS)

a. Configuration

The PTCS is used to monitor propellant loading and to control the replenish/adjust drain operations of the propellants in all Launch Vehicle stages. The PTCS consists of six separate systems to provide independent control of each tank or tank set. PTCS equipment is located in the LUT and in the LCC. Centralized control and monitoring of the automatic system is provided at PTCS consoles in the LCC.

The system operates in an automatic mode or a manual mode using separate equipment. The mode of operation is selected at the LCC consoles.

b. Failure Impact

Failure of the primary, automated mode of PTCS operation necessitates switchover to the manual mode. Failure in the transmission link between the AGCS and the LCC terminal equipment necessitates use of redundant transmission equipment.

Neither failure would significantly delay countdown operations.

c. Alternate Support

The primary, automated PTCS equipment is completely duplicated by means of a manual system, including sensor assembly, analog computing equipment, propellant control network, valve control assembly and transmission equipment.

1.14 Operational Intercom System (OIS)-RF

a. Configuration

The OIS-RF provides voice communciation between all major facilities of the Launch Complex, the industrial area and to outlying areas such as MSFC via LIEF and MSC via ALDS.

The OIS consists of 112 RF channels via coax cable and a supplementary 10-channel UHF link to the LUT while in transit. Each station of the system can communicate over any of its 112 channels.

Other equipment pertaining to the system include recording equipment for all or selected channels, failure detection equipment, displays for maintenance and interfacing equipment to the public address and paging system. The Switching and Monitoring Center is located in the Communications Control Room in the LCC.

b. Failure Impact

Failure of an individual channel requires switchover to an alternate channel.

Failure of a primary mission amplifier means loss of a Local Communications Area (LCA). Manual switchover to a secondary system takes some 5-10 minutes, except in cases of loss of Launch Pad LCA during hazardous operations. The repair time is increased for safing operations and transfer of repair crew.

In case of dual missions, and use of dual-mission amplifiers (primary and alternate), work around is necessary, requiring some 30 minutes.

c. Alternate Support

Automatic switchover capability is available between the individual channels assigned to a mission. Manual switchover to redundant equipment is available in case of amplifier and switching circuitry failure.

Power backup is provided through standby batteries.

During partial or complete loss of the OIS, temporary backup can be maintained via the public address or paging system, such as during the periods of manual switchover or repair.

1.15 KSC Tracking

a. Configuration

The KSC Tracking System comprises the ODOP System which provides trajectory information during first stage powered flight and can be used for impact prediction by the Range Safety Officer.

ODOP provided information is conditioned in the CIF and transferred to the ETR Real Time Computer System (RTCS) for processing. The processed data then is presented in the LCC. Provisions exist also to transmit ODOP data to ALDS for real-time analysis and to HOSC for post-flight analysis.

b. Failure Impact

Failure of the ODOP System does not critically affect the prelaunch or launch operations.

Participation of the ODOP System in a particular mission is not mandatory and loss of ODOP provided data is not considered critical.

c. Alternate Support

The primary systems for providing trajectory information and data for impact prediction are ETR's C-Band Radars and Azusa Systems. (See Section 3.21.) Plans exist to deactivate Azusa and increase the C-Band Radar capacity.

1.16 Apollo Launch Data Systems (ALDS)

a. Configuration

The ALDS is used to transmit selected uprange and downrange data from the CIF to MCC-H for flight control display purposes. A subsystem of the ALDS, the Countdown and Status Transmission Subsystem (CASTS) is specifically used to transmit countdown time and up to 120 countdown event signals. Another subsystem, the Apollo Launch Trajectory Data Subsystem (ALTDS), provides real-time trajectory data from liftoff through suborbital flight and provides impact point information from ETR's RTCS. The ALDS is located in the CIF and consists of two SDS 930 computers and associated interface equipment. Information is selected from either CIF Data Core for formatting and transmission to MSC.

Retrievable Data Core contents are obtained from CIF antennas, Tel IV, MILA USB site (including GSFC provided information), ETR (downrange), LCC TM station, DDAS and MSOB. The ALDS is designed for complete redundancy, including antennas, Data Core, computers, transmission links and terminal equipment at MSC.

b. Failure Impact

The ALDS is mandatory for launch operations. Loss of ALDS data means loss of real-time displays for coordinating MSC/KSC support operations and for trajectory analysis in early flight.

c. Alternate Support

The ALDS is operating in complete redundancy.

An additional backup capability exists via USB/GSFC. However, the USB link contains only low-bit rate telemetry data (2.4 kbs vs 40.8 kbs), which is not always sufficient for high accuracy systems evaluation. (Studies are presently being made for possible data rate increase.) In addition, the USB/GSFC route presents a delay factor of three (3) as compared to the ALDS link.

1.17 Mission Control Center - Houston (MCC-H)

a. Configuration

Principal subsystems of MCC-H are the Mission Operations Computer System (MOCS), the Communications Command and Telemetry System (CCATS) and the Mission Operations Control Room (MOCR).

ALDS and MSFN telemetry and tracking data is acquired by the two Univac 494 computers of CCATS for formatting and switching to the MOCS (IBM 360/75), DCS. The CCATS computers operate in parallel for both ALDS and MSFN data.

The MOCS processes data for displays and analysis by the flight controllers in the MOCR and prepare the real-time commands for the DCS. Of the four IBM 360/75 computers available at MCC-H, any combination for operating the MOCS can be established, such as one computer for each of the two MOCR's with redundant backup, or two parallel computers for one MOCR with space for program development or mission simulations.

b. Failure Impact

Proper MCC-H operation is launch and mission mandatory. Failure of any of the major MCC-H systems, CCATS, MOCS or MOCR necessitates switchover to the standby systems. Since all backup systems operate in a standby mode, the loss in time depends on the required manual switchover operation.

c. Alternate Support

Other than the completely redundant MCC-H systems, no alternate support is available.

1.18 Unified S-Band Station (USB Station)

a. Configuration

The USB station is used (1) to transfer MCC-H generated command loads to the LVDC and AGC memories which contain ephemeris and maneuver data, (2) to generate and transfer real-time commands for CSM and LV switch selection and operation and (3) to accept and transfer telemetry data, containing system status information.

The USB station contains S-Band and UHF antennas for telemetry and commands, two Univac 642B computers, one for the telemetry and one for the command data; flight controller consoles and terminal equipment for both 40.8 kbs and 2.4 kbs data links. Interfacing with the USB station are incoming data links (40.8 kbs) from CIF/ALDS and incoming command links (2.4 kbs) from MCC-H via GSFC; outgoing command links (2.4 kbs) as part of the DRUL (Down Range Updata Link), outgoing data links (2.4 kbs) to the GSFC communications processors for transfer of TM data to MCC-H and MSFN, and outgoing data links (2.4 kbs) to CIF's Data Core.

During prelaunch operations, the USB site is required for all MCC-H/KSC interface tests, which consist of the SIT, SFT, FRT, CDDT and CD. The 2.4 kbs links carry the TM data of the inflight configuration and data rates, the 40.8 kbit links (ALDS) carry the data of the prelaunch configuration and at a higher sampling rate, which is required to establish base line data records and to provide increased accuracy. During countdown, launch and first phase of flight, the command link via USB site provides backup command capability for on-board, LVDC program controlled, operations and present one out of two cues to the Abort Advisory System interfacing with the astronauts. (The second cue is presented via voice link.) During the flight, the remote sites of the MSFN perform the command and telemetry functions of the USB site.

b. Failure Impact

During SIT, SFT, FRT, CDDT, CD, launch and early flight, operational support by the USB station is mandatory. Loss of the USB site disables MCC-H/KSC interface capability for command support completely, and for TM data transfer partially.

c. Alternate Support

Alternate command and TM support is available locally at KSC and provides at least a temporary support capability during prelaunch operations with partial substitution of MCC-H by means of the RCA-110A system and ACE-SC.

Within the USB station, limited redundancy exists between the command and telemetry computers which are programmed to perform the alternative function in a reduced mode of operation.

Local command and telemetry support is available through the RCA-110A systems to the LVDC and through ACE-SC to the AGC. However, command control through ACE-SC is discontinued after SC closeout (T-14 hrs.) and the discrete output control through the RCA-110A system is locked out with the start of TCS operation (T-187 sec.).

Prelaunch flight TM and certain checkout TM is also available through hardline and RF links via ALDS on the 40.8 kbs data links. Current planning considers duplication of all USB station essential equipment, including TM and command antennas and computers. The primary reason for the duplication is dual mission support; this duplicate configuration, however, will also provide complete backup capability.

1.19 Launch Information Exchange Facility (LIEF)

a. Configuration

LIEF is used to transfer information between KSC and MSFC (1) to provide engineering support in the areas of propulsion, navigation and electrical networks, (2) to provide advisory support relative to the launch environment, specifically wind condition, (3) for post-test data analysis. TM data is retrieved from the CIF Data Core and prepared by two special-purpose computers located in the CIF for transmission to MSFC via the 40.8 kbs data links. MSFC received data is processed by the Burroughs B5500 computer for display at HOSC. Data retrieval from the CIF's Data Core is controlled by MSFC via the 2.4 kbs data link.

LIEF is used during such tests as OAT #1, OAT #2, FRT, CDDT, CD and some special tests. Primary communication with KSC is via voice link.

b. Failure Impact

Failure of LIEF does not interrupt the launch operations.

LIEF is primarily a monitoring system and is classified as highly desirable. No command link exists between MSFC and KSC. However, for certain AAP experiments, where the experiment responsibility lies with MSFC, additional command capability might become necessary and with it a reclassification of LIEF to mandatory.

c. Alternate Support

Redundant data processors exist in the CIF for retrieving data from the Data Core. However, no other redundant equipment is provided in the LIEF and HOSC systems and no alternate support capability exists.

1.20 ETR Timing System

a. Configuration

The ETR Timing System provides timing to launch sites and instrumentation sites, including the ETR RTCS. The Timing System consists of (1) the central timing station at Cape Kennedy, (2) the downrange central timing stations, and (3) the subcentral timing units for the instrumentation stations on the Florida mainland. Every central timing station generates its own timing code by means of redundant pulse generators.

Overall synchronization is achieved through (1) the WWV network to within ±5 millisec. signal correlation, (2) the Loran-C equipment to within ±100 microsec., or (3) the signals from the ETR subcable to within ±40 microsec. signal correlation.

The KSC timing system is synchronized with ETR also and has additional synchronization capability through WWV and Loran C.

The subcentral timing units receive the timing signals from the central timing stations. The subcentral timing units provide the timing signals, position identifiers and pulse rates to Television and Tracking Camera equipment.

The RTCS is part of the Range Safety System and provides vehicle position display and impact prediction.

b. Failure Impact

Loss of ETR timing disables primary KSC and downrange synchronization, which, however, does not critically impact prelaunch operations, launch or flight.

Loss of instrumentation site operation (Television and Tracking Camera) is not critical except for special mission requirements.

Loss of RTCS operation is critical with regard to range safety operations and for providing information to ALDS. (See Section 3.21.)

c. Alternate Support

The ETR timing system is designed to operate in a redundant standby mode. If primary and secondary equipment is lost, primary central timing is available at the downrange sites and alternate synchronization is provided through Loran C and WWV equipment. This applies to KSC timing also, where CIF provides the primary central timing, and synchronization is achieved through WWV and Loran C. No backup capability is provided for driving the subcentral timing units and their associated instruments which, however, are not launch critical.

1.21 Range Safety System

a. Configuration

The Range Safety System provides vehicle position and velocity information from launch through burnout or attainment of orbital speed. Tracking data is used to compare the actual with the nominal trajectory and to compute instantaneous impact prediction. Signals for flight control or emergency destruct are issued by the ETR Command and Launch System.

Principally, the Range Safety System contains equipment for vehicle tracking, data processing, data display, data recording and command control.

The principal tracking equipment for Saturn vehicles consists of the C-Band Radar System, operating in a redundant configuration.

The data processing equipment includes two CDC 3600 computers, located in the Cape Kennedy Industrial Area. The display and recording equipment includes plotting charts, television displays, printers and tapes. ETR processed data is available in the Range Safety Control Center located at the Cape Kennedy Industrial Area and in the CIF for distribution to the LCC's of LC 34, LC 37 and LC 39 and for ALDS and LIEF. The Command and Control System contains the FRW-2 UHF transmitters, which operate in a standby configuration with automatic switchover capability.

b. Failure Impact

Failure of the Range Safety System disables the capability for predicting impact locations or determining in limit flight performance for safety purposes.

Operation of the Range Safety System is mandatory for all integrated prelaunch tests, launch and powered flight.

c. Alternate Support

All principal equipment of the Range Safety System, including the means for tracking, data processing, display and command control, are provided in redundant configuration.

In case of loss of any system function, no means for providing this function is available other than by the specific equipment and its alternate.

1.22 Hardline Communications System

a. Configuration

Figure 2 depicts the hardline system which provides distribution and switching for all data, including timing signals, vehicle checkout and launch information, acquisition and trajectory information, command and control signals, OIS and Television. It also includes the interface links to ETR, MSC, MSFC, GSFC (MSFN), commercial communication and paging systems. The principal transmission equipment includes (1) the wideband data links (A2A) used for TV, OIS, DDAS, ACE-SC, and TM exchange between LCC/CIF/USB station and ETR and (2) the high speed telephone lines (19 gauge) used for (a) the timing system (b) the broad-band TM (40.8 kc) for ALDS, LIEF, and downrange cable, (c) Flight TM and Command Control (2.4 kc) between Launch Complex, Industrial Area, USB-station and GSFC; and (d) such ancillary functions as teletype and facsimilie.

All transmission lines interface with the CDSC, which provides for cross-connecting the incoming and outgoing lines.

Additional cross-connecting facilities are provided in the VAB; all A2A lines from and to LC-39 are routed via this repeater.

The interface point for all circuits between KSC and ETR is provided at the BRR Station.

b. Failure Impact

Availability of communication links between Launch Complex facilities, MSOB, CIF, USB-Station, ETR, GSFC (MSFN) and MCC-H is mandatory for countdown and launch.

Catastrophic events (fire, power failure) in central equipment and resulting loss of such facilities on the CDSC can disable all communications via hardlines. Other points of concentrated failure impact are the BRR and VABR.

c. Alternate Support

Each group of communications circuits contain at least one set of spare equipment, to which the function of a failing circuit can be switched. At the present time,

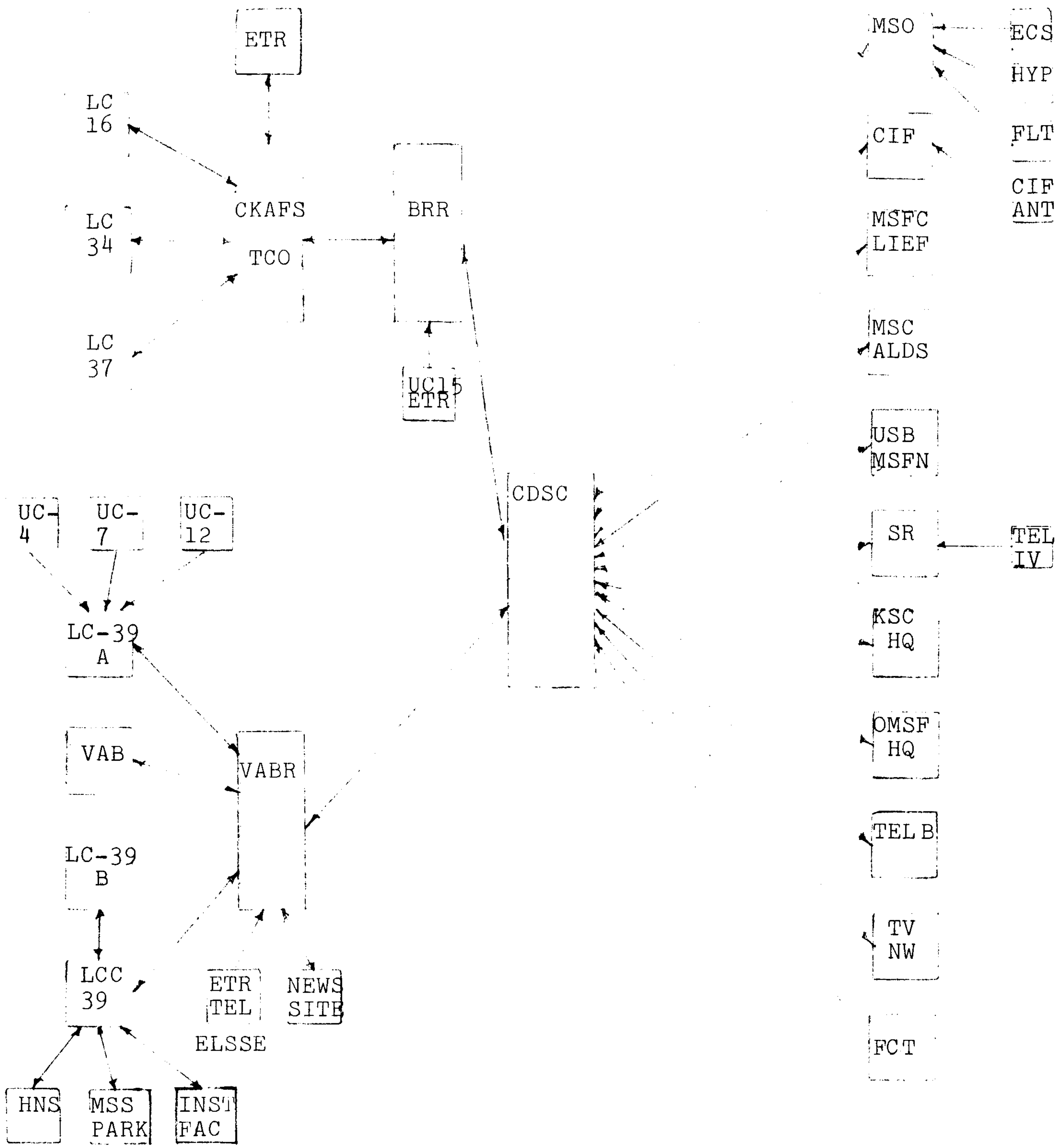

FIGURE 2

BLOCK DIAGRAM OF INTRA- AND INTER-KSC
WIDEBAND TRANSMISSION LINKS

failure of a circuit is presented automatically, patching to an alternate circuit occurs manually. This operation can require considerable time, particularly, in case of circuit failure in the launch areas and during phases of "Pad Clear" or "Limited Access" operations. This circumstance has initiated efforts to provide for automatic switchover capability.

Additional communications exist to some extent via open-loop links.

1.23 Open Loop Communications System

a. Configuration

Open-loop facilities are provided at (1) the CIF to acquire SV TM checkout and Flt. TM data, (2) the LCC to acquire LV TM data and Voice, (3) the MSOB to acquire SC TM data and Voice, (4) the USB-Station to receive both TM data and Voice and to transmit command and update information, and (5) ETR's FRW 2 equipment to transmit command signals as part of the Abort Advisory and Emergency Destruct Systems. (See Figure 1.)

b. Failure Impact

Failure of the open-loop communication system disables ACE checkout capability of the ground and flight systems in the mission configuration.

All open-loop equipments are mandatory for plugs-out, FRT, CDDT and special RF tests, and during countdown and launch.

c. Alternate Support

TM can be received via S-Band at the CIF and USB-Stations. VHF equipment is available at the LCC and CIF TM stations, the USB site and at Tel II (ETR) and Tel IV.

No alternate support is available for the USB update or command links. (See Section 1.18 also.)

ATTACHMENT 2

LIST OF ABBREVIATIONS

AAP	Apollo Applications Program
ACE-SC	Acceptance Checkout Equipment-Spacecraft
AFETR	Air Force Eastern Test Range
AGC	Apollo Guidance Computer
ALDS	Apollo Launch Data System
ALTDS	Apollo Launch Trajectory Data System
BRR	Banana River Repeater
CASTS	Countdown and Status Transmitting System
CCATS	Communications Command and Telemetry System
CD	Countdown
CDDT	Countdown Demonstration Test
CDSC	Communication Distribution and Switching Center
CIF	Central Instrumentation Facility
CKAFS	Cape Kennedy Air Force Station
CRT	Cathode Ray Tube
CSM	Command Service Module
DCS	Digital Command System
DDAS	Digital Data Acquisition System
DEE	Digital Events Evaluator
DTS	Data Transmission System
ECS	Environmental Control System
EDS	Emergency Destruct System
ELLSE	Electronic Skyscreen
ESE	Electrical Support Equipment
ETR	Eastern Test Range
FRT	Flight Readiness Test
G&C	Guidance and Control
G&N	Guidance and Navigation

GMT	Greenwich Mean Time
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HOSC	Huntsville Operations Support Center
IU	Instrument Unit
KSC	Kennedy Space Center
LC	Launch Complex
LCA	Local Communications Area
LCC	Launch Control Center
LIEF	Launch Information Exchange Facility
LOX	Liquid Oxygen
LUT	Launch Umbilical Tower
LV	Launch Vehicle
LVDC	Launch Vehicle Digital Computer
LVO	Launch Vehicle Operations
MCC-H	Mission Control Center-Houston
MILA	Merritt Island Launch Area
MOCR	Mission Operations Control Room
MOCS	Mission Operations Computer System
MSOB	Manned Spacecraft Operations Building
MSR	Mission Support Room
OAT	Overall Test
ODOP	Offset Frequency Doppler
OIS	Operational Intercom System
PTCS	Propellant Tanking Computer System
RCS	Reaction Control System
RTCS	Real Time Computer System (ETR)
SC	Spacecraft
SFT	Simulated Flight Test
SIT	Software Integration Test
TCS	Terminal Countdown Sequencer
TM	Telemetry
UHF	Ultra High Frequency
USB	Unified S-Band
VAB	Vehicle Assembly Building

VABR	VAB Repeater
VLF	Very Low Frequency
WWV	National Bureau of Standards Transmitter, Beltsville, Maryland